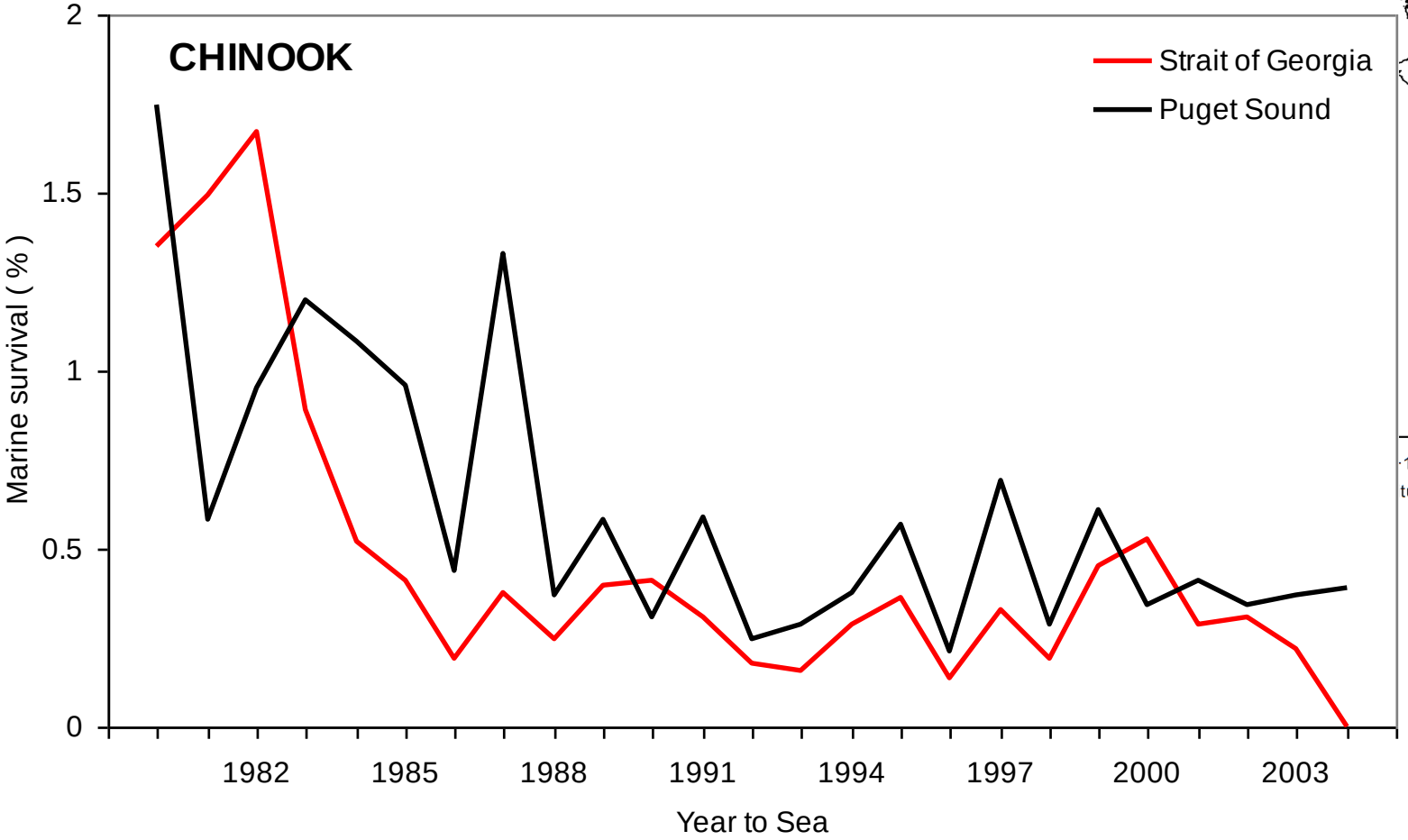
Salish Sea Marine Survival Project

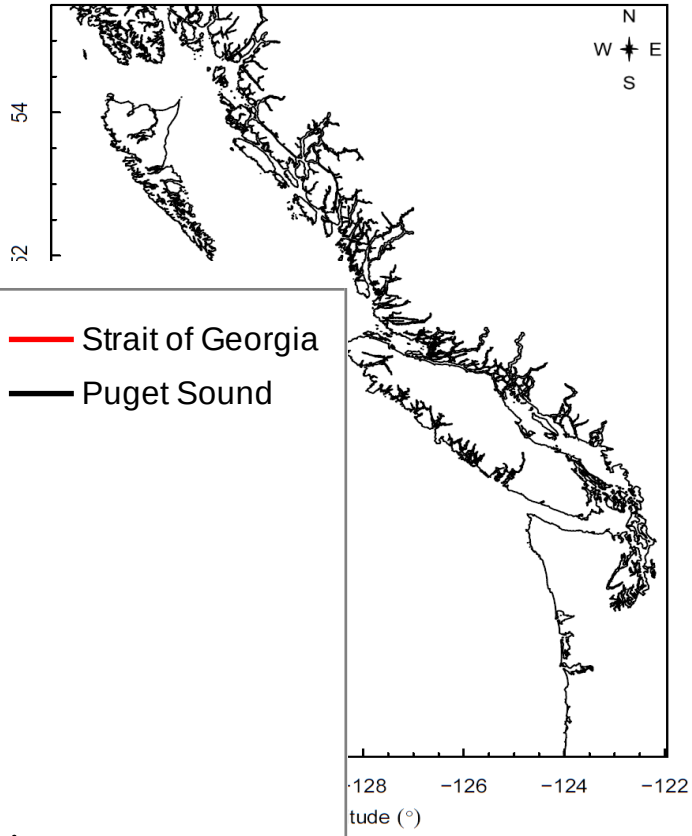
LONG LIVE THE KINGS

PACIFIC SALMON FOUNDATION

Evidence changes unique to the Salish Sea are affecting survival

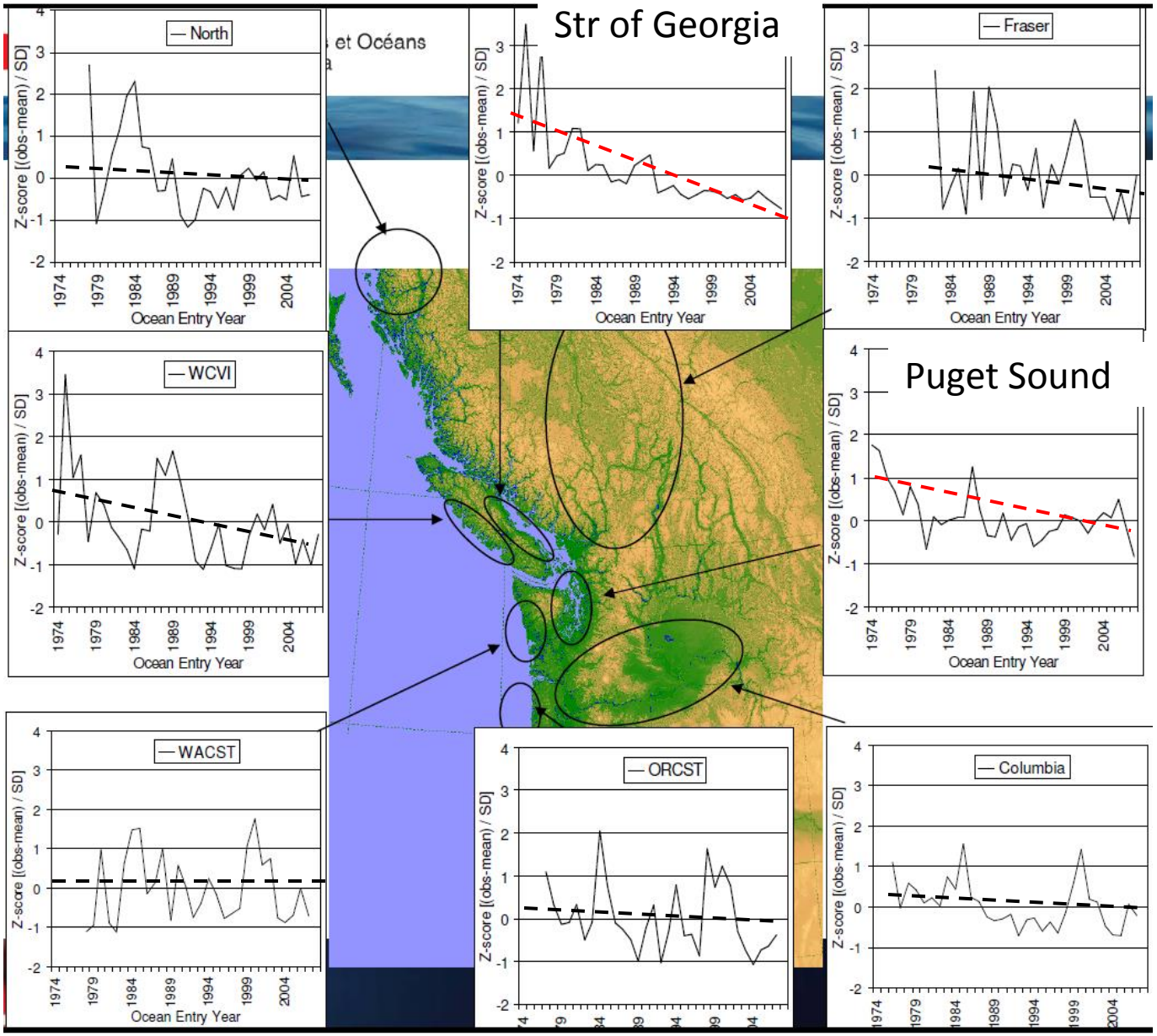
Marine survival of hatchery Chinook from the Salish Sea region





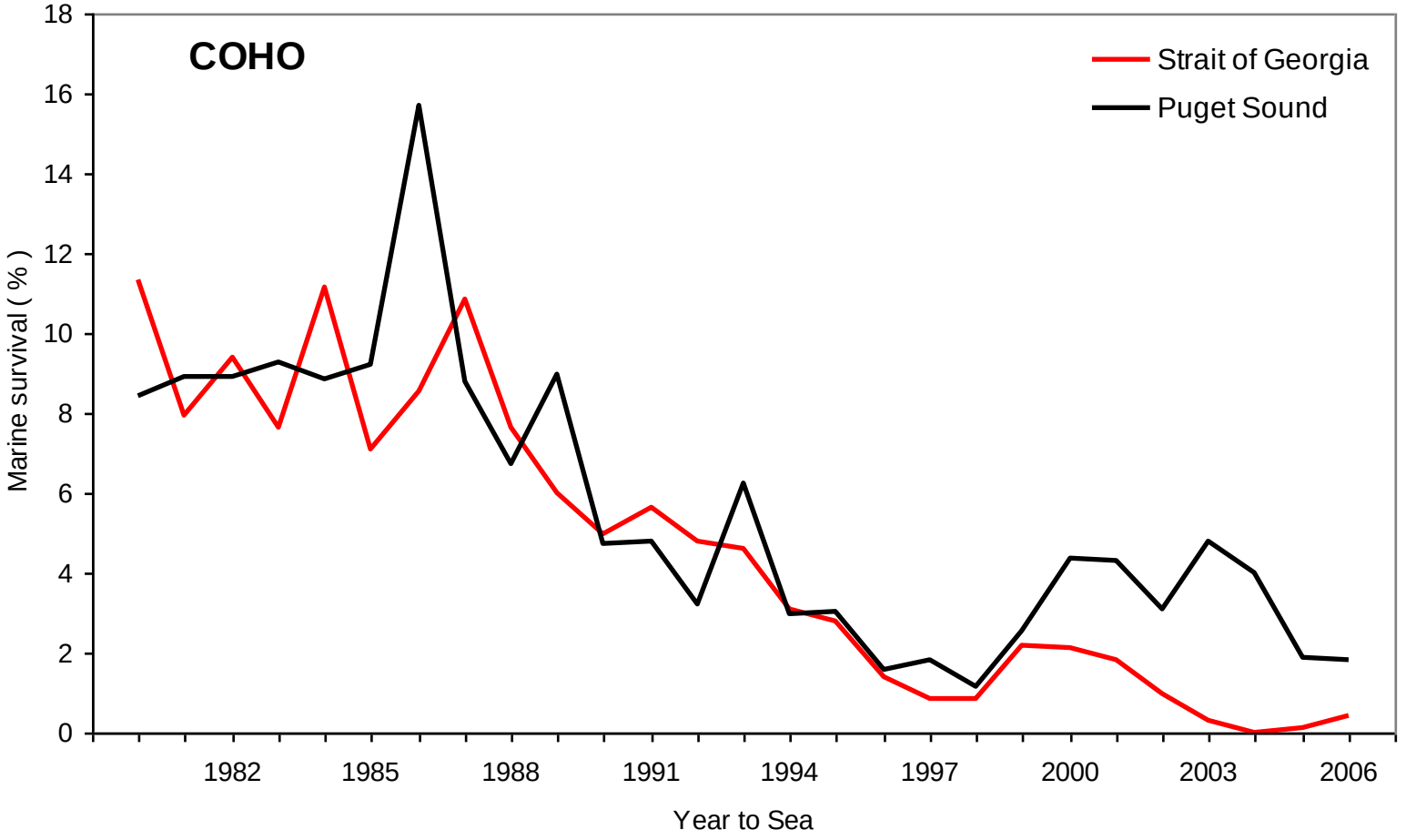
Beamish 2011.

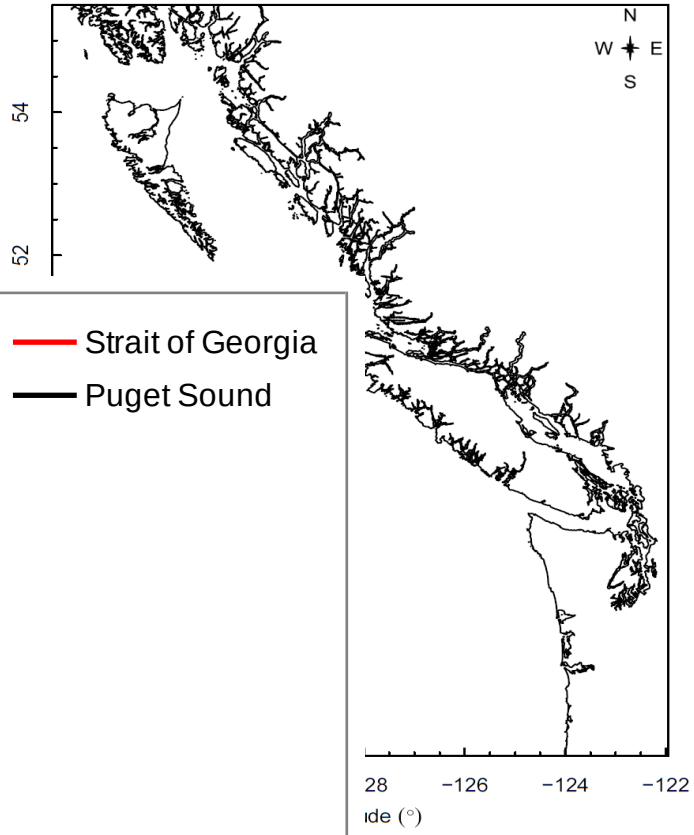
Chinook marine survival: a regional comparison



Whitehouse & Tompkins. 2010.

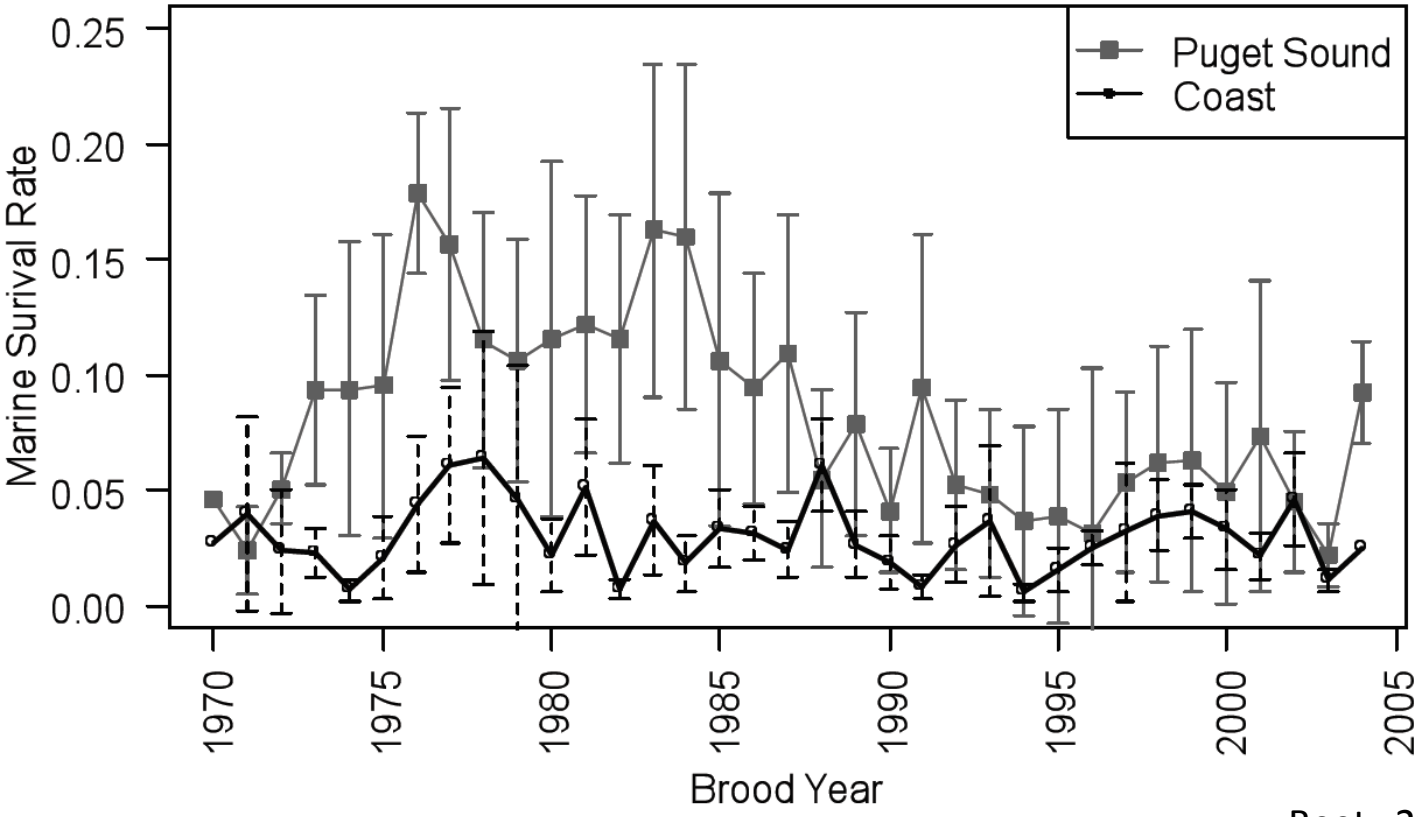
Marine survival of hatchery coho from the Salish Sea region

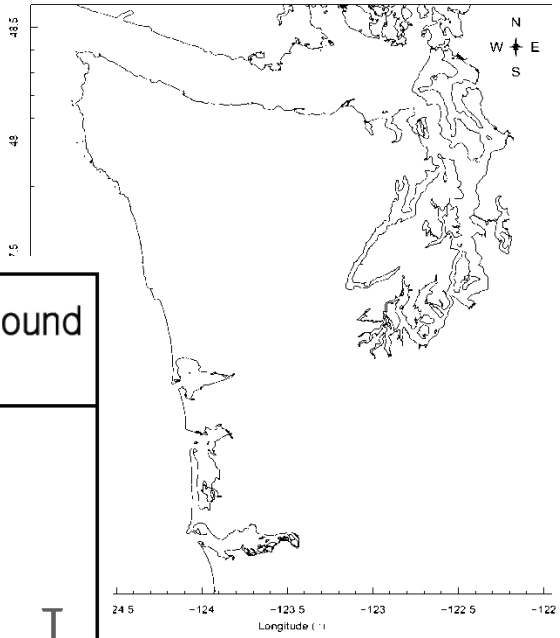




Beamish 2011.

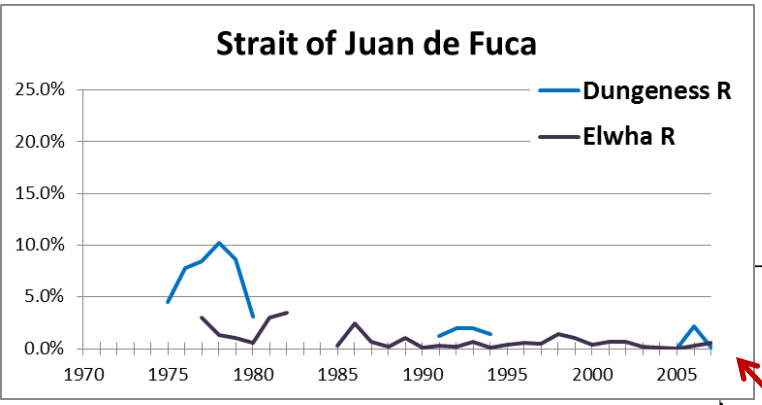
Marine survival of hatchery and wild coho: Puget Sound vs. Washington Coast

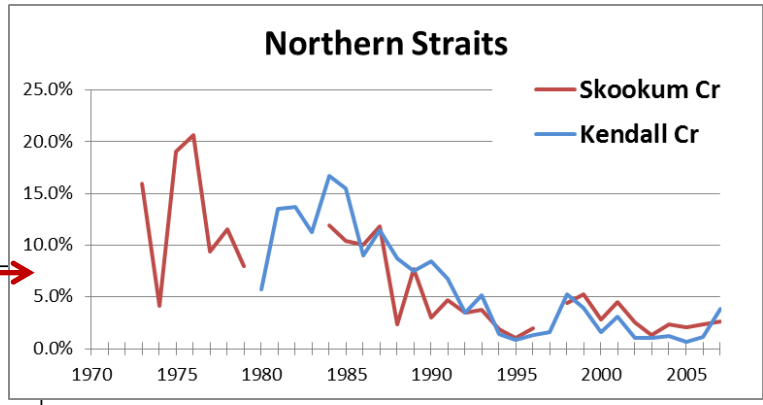


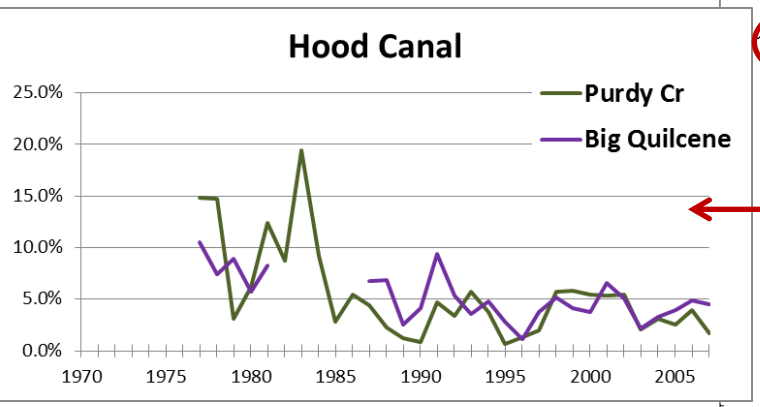


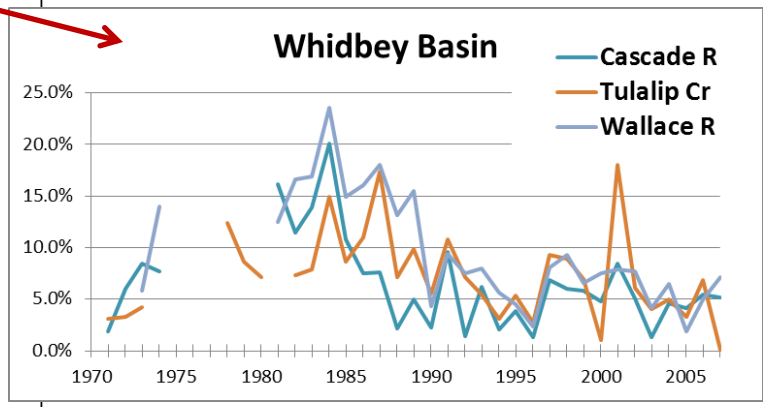
Beetz 2009

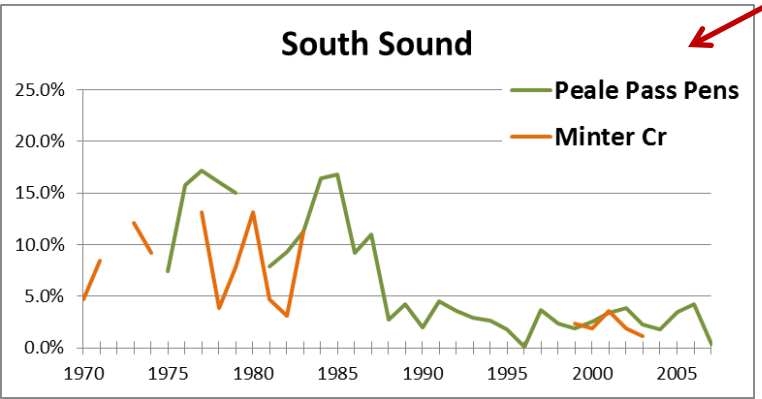
Puget Sound hatchery coho marine survival

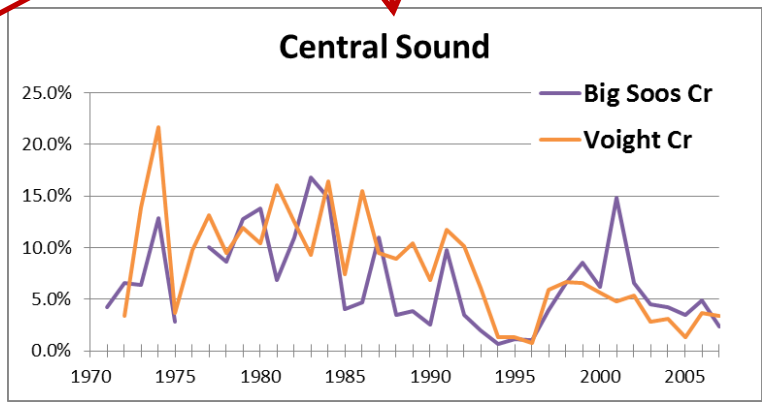


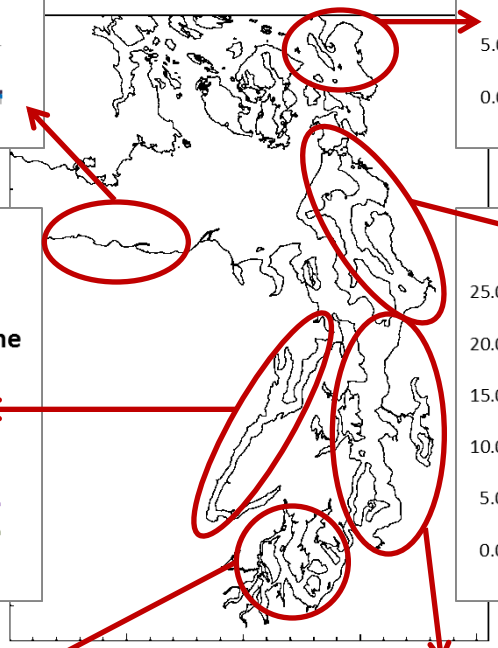






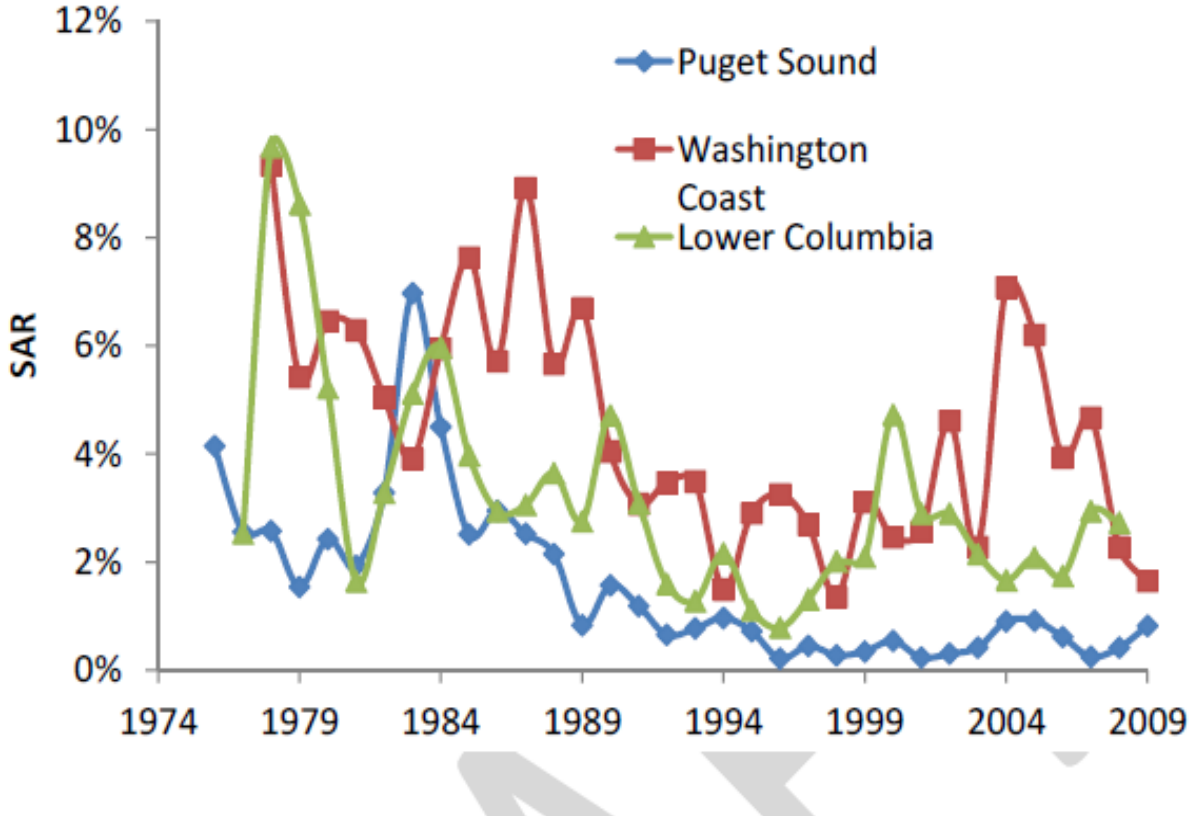






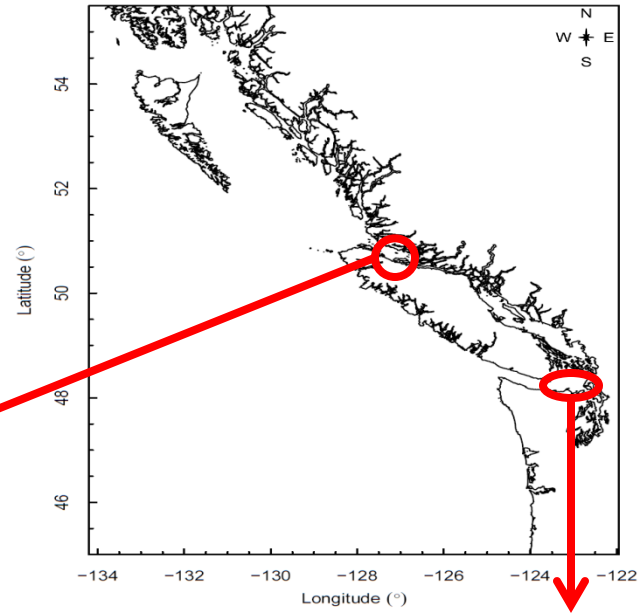
Haymes, J. WDFW.

Marine survival of hatchery steelhead: Puget Sound vs. other regions

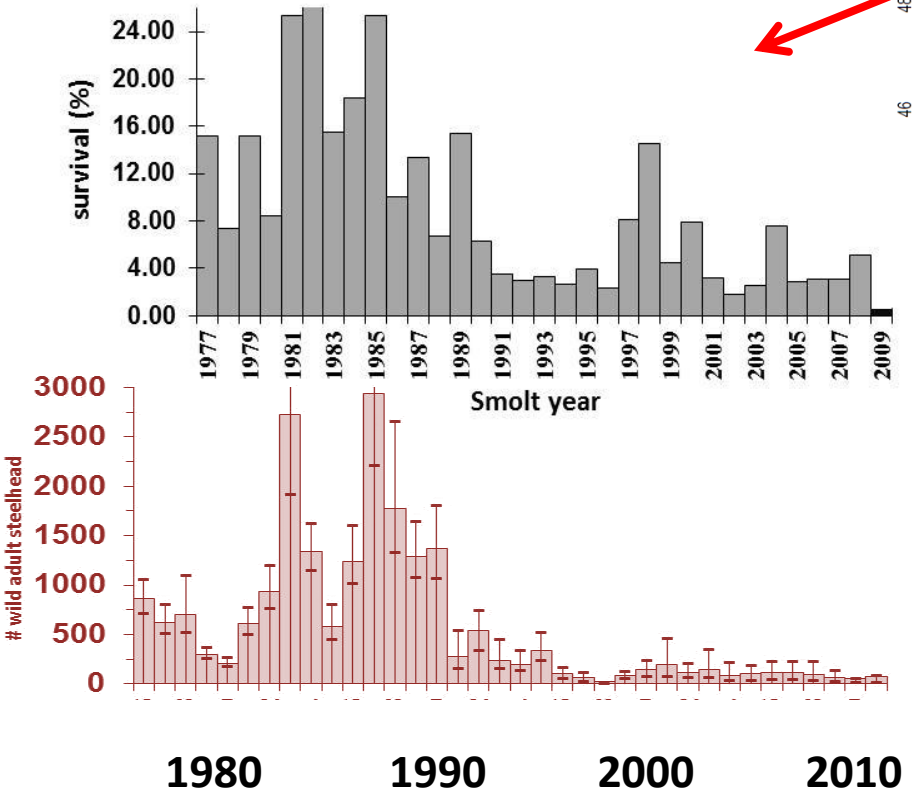


Data compiled by I. Kemp. 2012

Wild winter steelhead marine survival in the Salish Sea and its correlation with abundance:

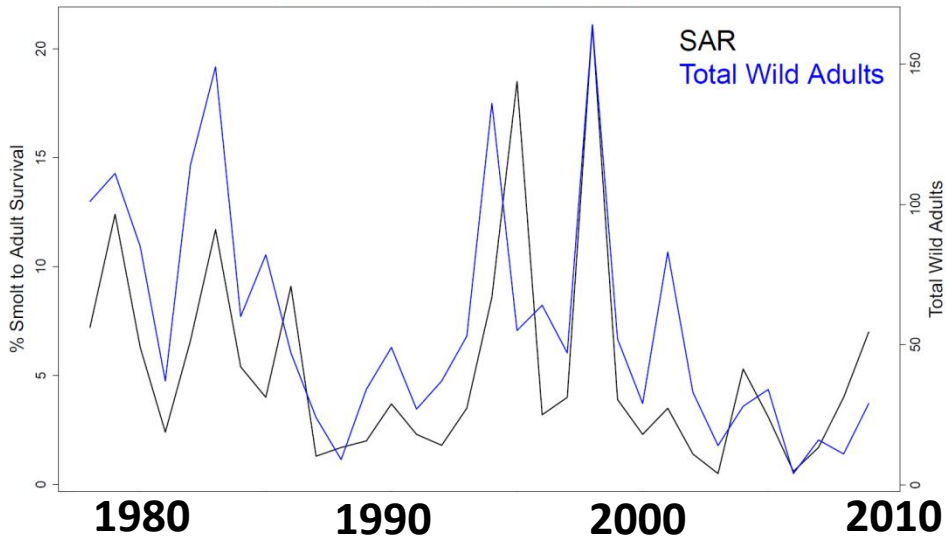


Keogh River Winter Steelhead



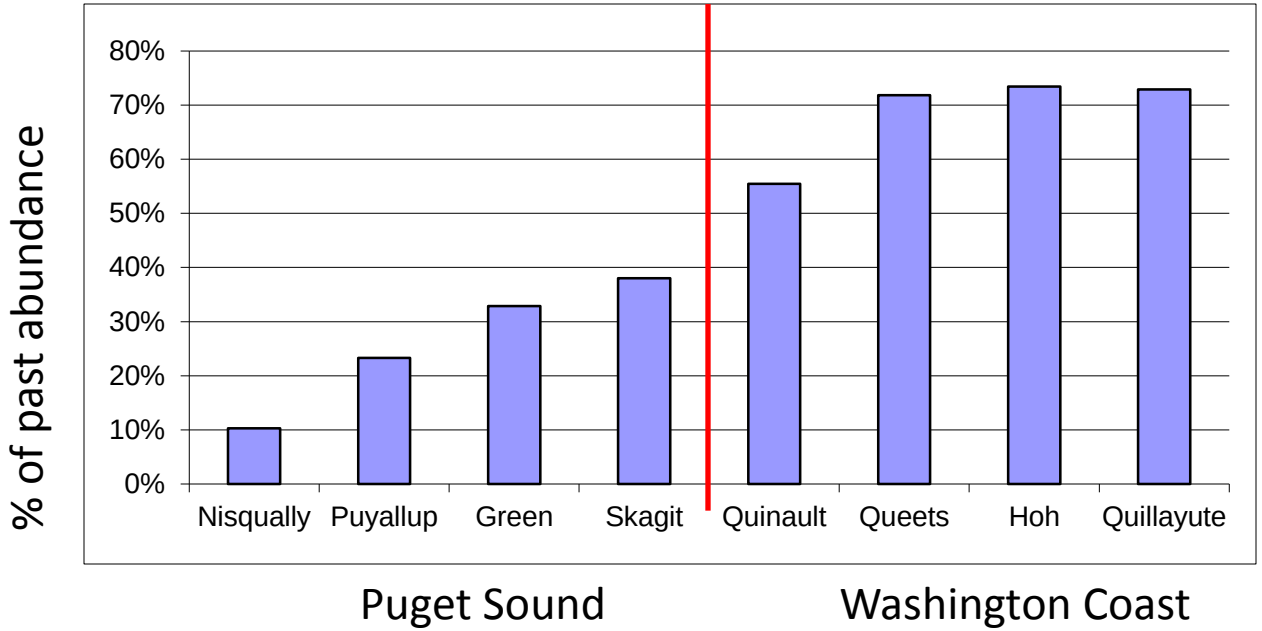
Pollard, S. & Beere, M. 2012

Snow Creek Winter Steelhead

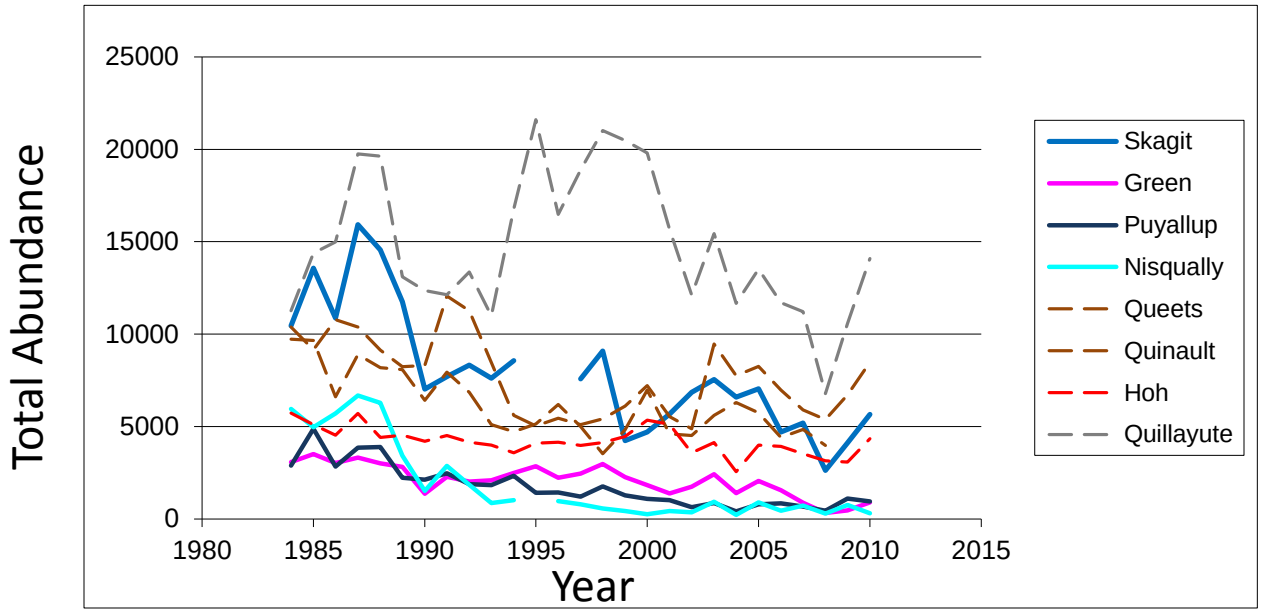


Data from WDFW 2012

Change in return abundance: Avg 2005-2010 divided by 1984-1989



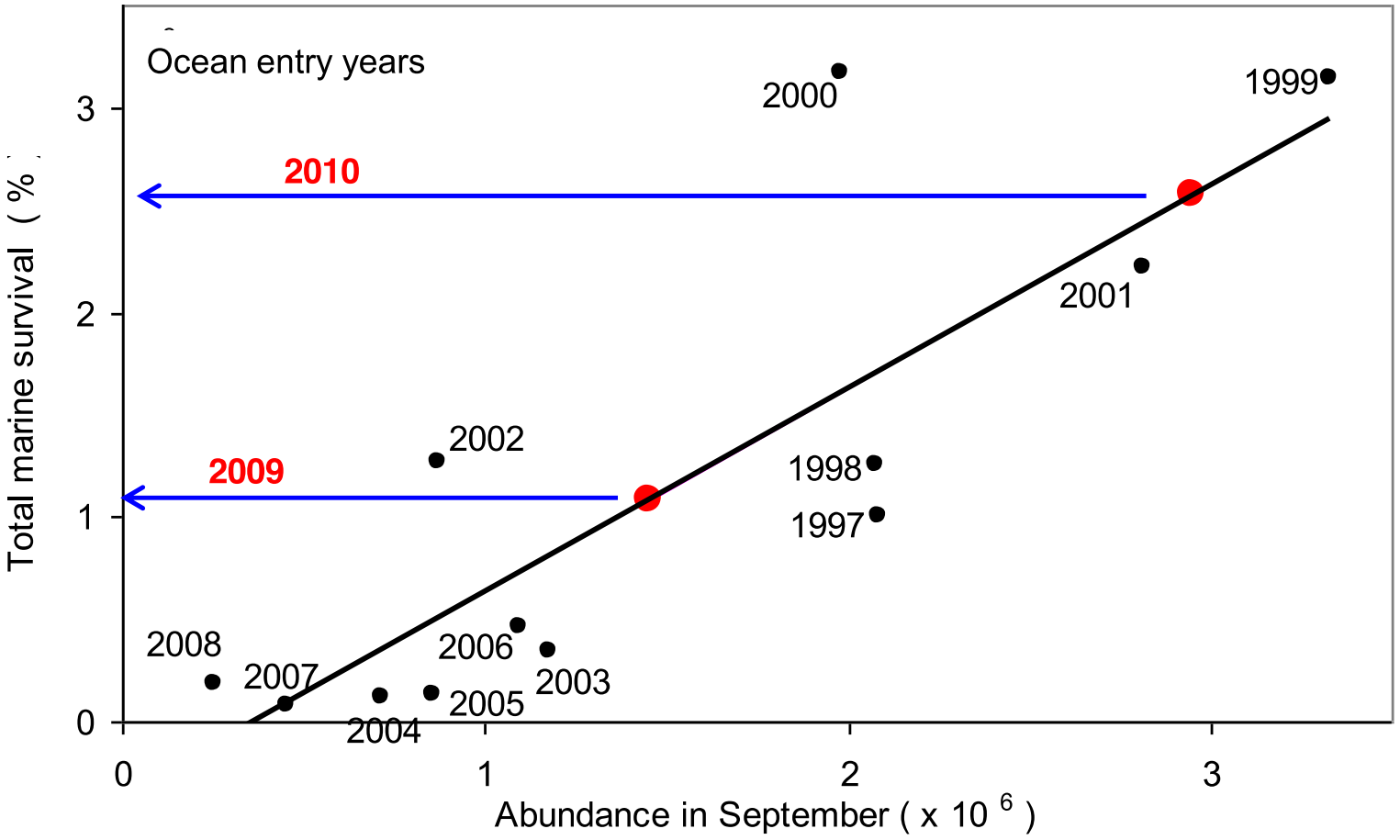
Trends in adult return abundance: Puget Sound and Coast



Data provided by B. Leland via K. Warheit 2013

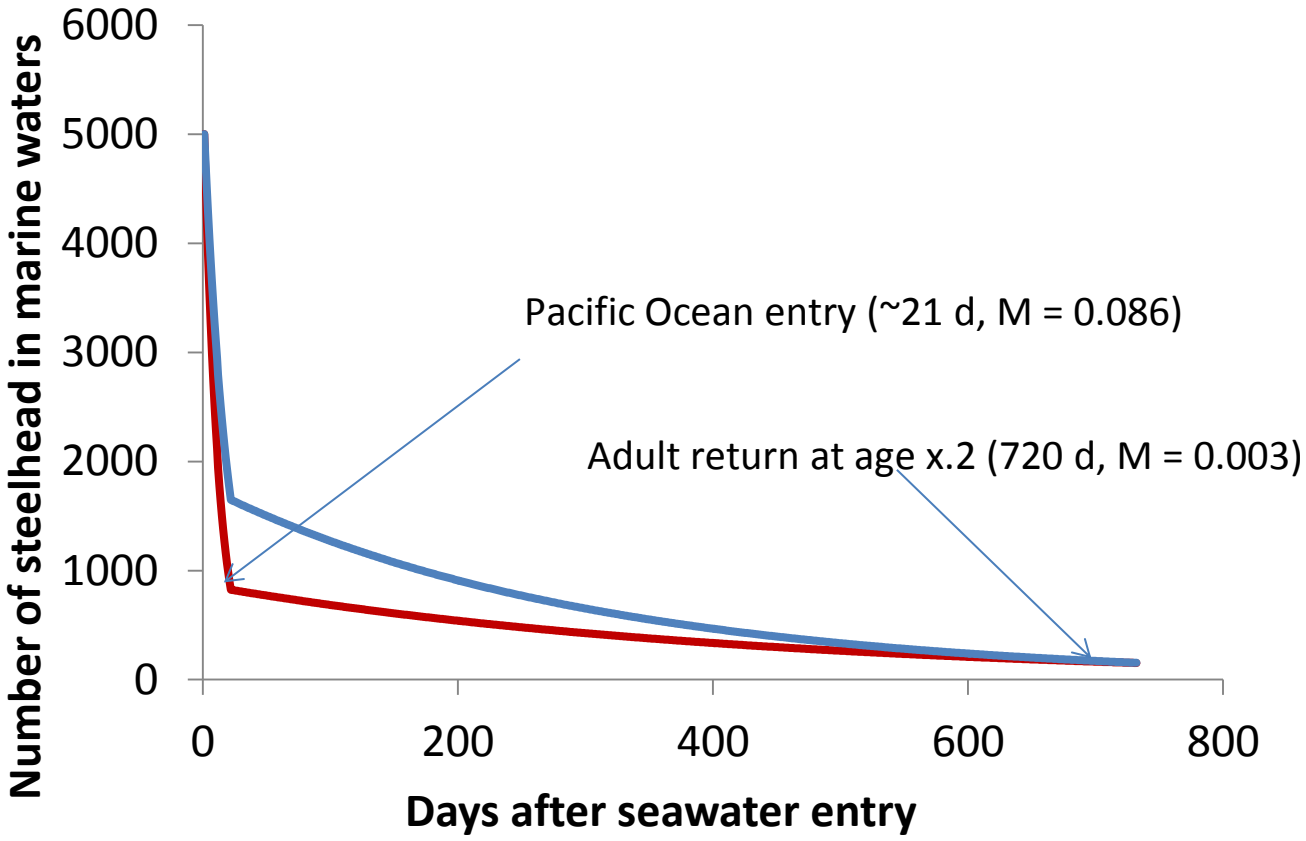
Evidence that early marine survival of juvenile salmon and steelhead strongly influences total marine survival

There is a strong relationship between the swept volume abundance in September and the total marine survival of coho salmon



Beamish 2012

Steelhead: Puget Sound vs Ocean Survival



Moore and Berejikian 2012

Salish Sea Marine Survival Project

Objective: "Identify the most significant factors affecting the survival of salmon and steelhead in the Salish Sea marine environment."

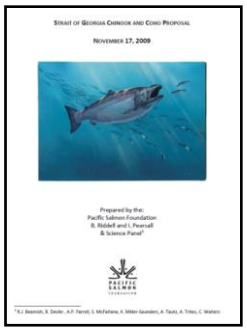
Baseline Assumptions:

- Salmon-Salish Sea interaction very complex.
- High uncertainty and likely multiple factors at play, with some dominating.
- Therefore, an ecosystem-based, multi-disciplinary approach is required.

Salish Sea Marine Survival Project Process

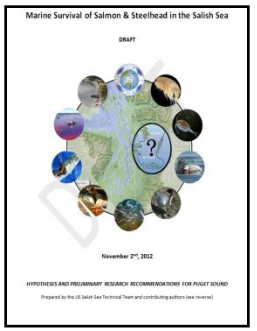
Comprehensive research planning
(1-1.5 years, done in 2013)

Canada

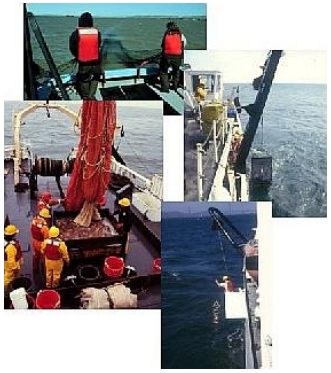


Workshop +
New Information

US



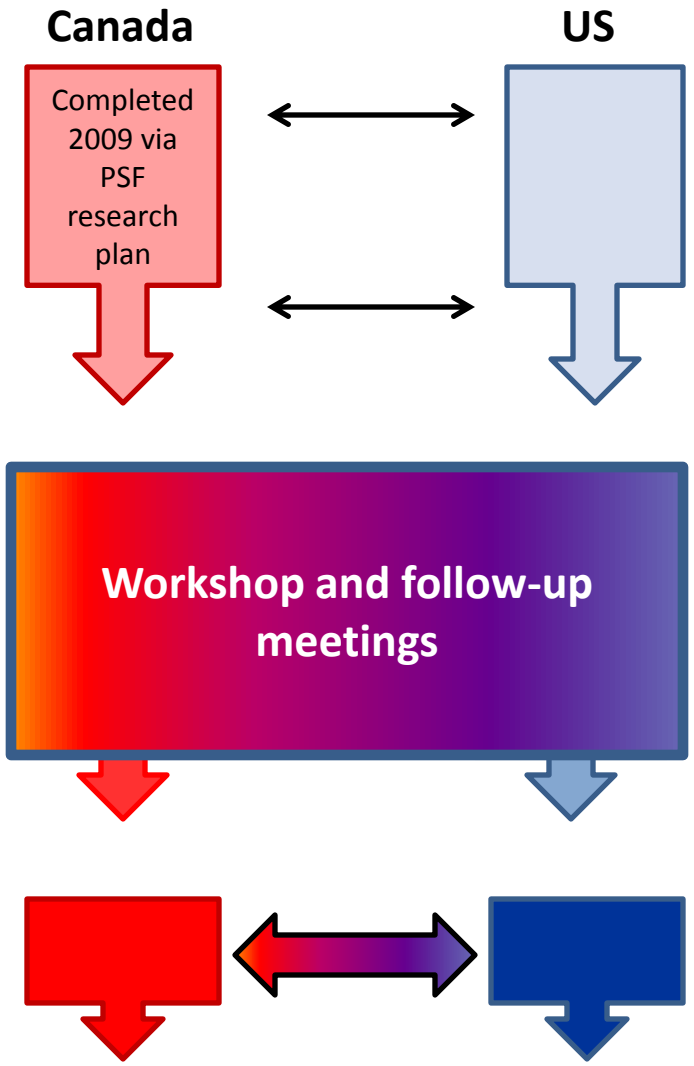
Coordinated, systematic research
(5 years)



Dissemination and application of the research results to management.
(1 year)

Salish Sea Marine Survival Research Planning Process

- ✓ Develop operational structure, conceptual framework, hypotheses and preliminary research recommendations
- ✓ US- Canada Salish Sea Marine Survival Workshop
- ✓ Complete workshop summary report identifying critical elements of collaborative US-Canada research program
- • Develop coordinated research plans.



Operational Structure - US

Nonprofit Support

- Project management, coordination and facilitation
- Fundraising and Communications
- Support integration with other programs

LONG LIVE THE KINGS
Celebrating 25 Years!

Coordinating Committee

(Management)

- Program guidance
- Fundraising
- Respond to research outcomes

Technical Team

(Science)

- Plan and implement research

Supporting Experts

(Science - Affiliated research)

- Assist w/ research planning and implementation

NOAA
NWIFC
NISQUALLY INDIAN TRIBE
PugetSoundPartnership
LEADING PUGET SOUND RECOVERY
USGS
science for a changing world
TULALIP TRIBES
LUMMI NATION
TREATY OF 1855
U.S. FISH & WILDLIFE SERVICE

US Technical Team Participants

Dave Beauchamp	U. Washington / USGS	**Ecology: food web, bioenergetics**
Barry Berejikian	NOAA NWFSC	**Ecology: behavior, life history; hatcheries**
Josh Chamberlin	NOAA NWFSC	**Ecology**
Alan Chapman	Lummi Nation	**Harvest, Hatcheries, Biology**
Mike Crewson	Tulalip Tribes	**Hatcheries, Harvest, Biology**
Chris Ellings	Nisqually Tribe	**Ecology and habitat**
Correigh Greene	NOAA NWFSC	**Ecology**
Paul Hershberger	USGS	**Disease**
Julie Keister	U. Washington	**Zooplankton eco./ oceanography**
Jan Newton	U. Washington	**Phys/biological oceanography**
Sandi O'Neill	WDFW	**Toxics**
Ken Warheit	WDFW	**Genetics**
Neala Kendall	WDFW	**Steelhead Ecology**

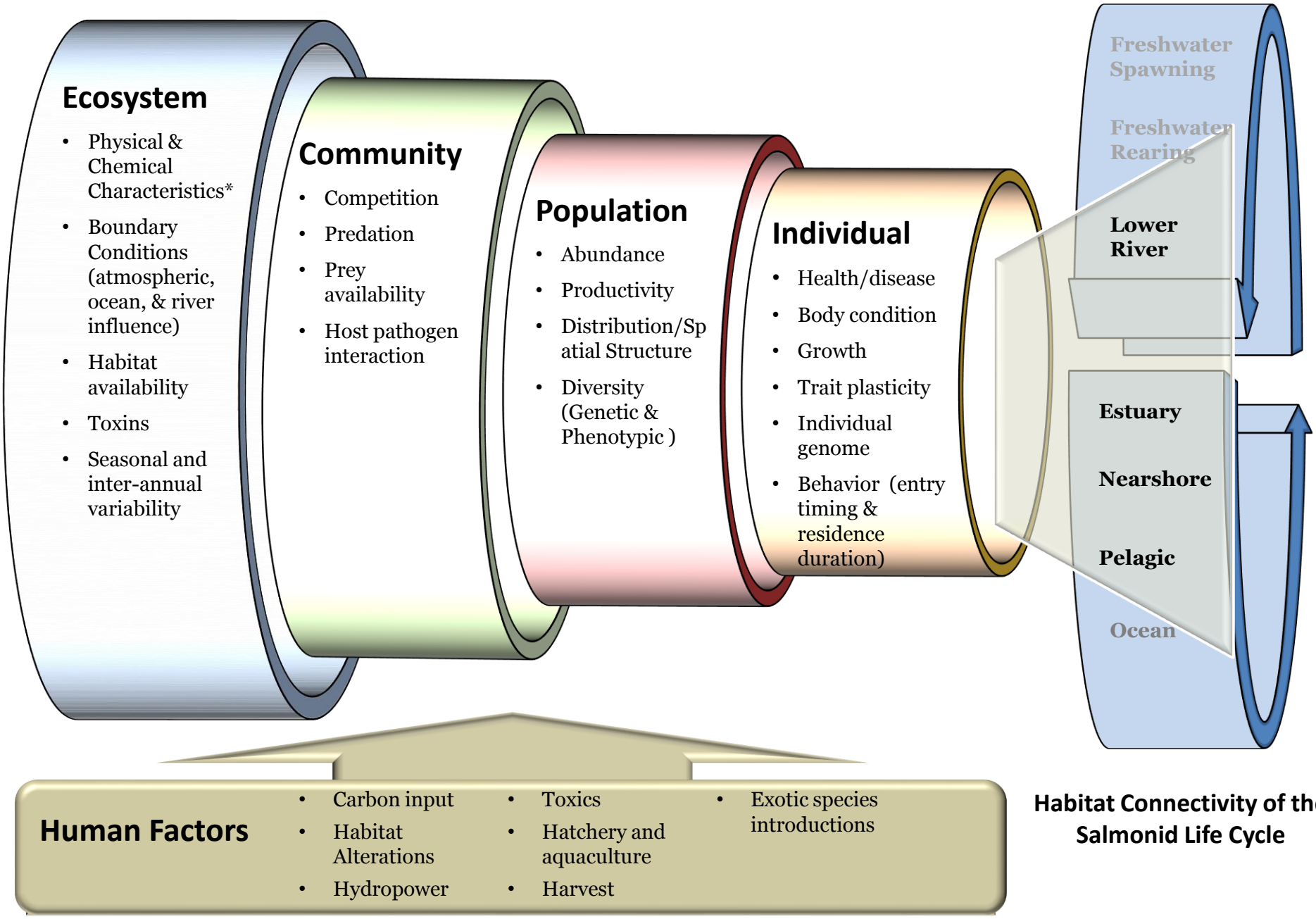
Other Contributing Scientists

Neil Banas	U. Washington	**Biological oceanography/modeling**
Ed Connor	Seattle	**Ecology, life history and behavior**
Chris Harvey	NOAA NWFSC	**Ecosystem modeling**
Sayre Hodgson	Nisqually Indian Tribe	**Ecology and habitat**
Lyndal Johnson	NOAA NWFSC	**Toxics**
Parker MacCready	U. Washington	**Physical oceanography/modeling**
Nate Mantua	U. Washington	**Climate, ecology, oceanography**
Paul McElhany	NOAA NWFSC	**Ocean acidification**
Megan Moore	NOAA	**Ecology, steelhead acoustic telemetry**
Erik Neatherlin	WDFW	**Salmon biology**
Scott Pearson	WDFW	**Avian and marine mammal ecology**
Jack Rensel	Rensel Assoc.	**Harmful algae**
Mara Zimmerman	WDFW	**Ecology: wild salmon prod. eval.**

Puget Sound Research Planning: Scope

- Juvenile **Chinook, coho, steelhead,** chum, pink, and sockeye (inc. resident forms)
- Geographic areas: lower river, estuary, nearshore, pelagic
- Inc. health/condition of fish as they enter & leave the Salish Sea

Puget Sound Research Planning: Conceptual Framework



Habitat Connectivity of the Salmonid Life Cycle

Puget Sound Preliminary Research Recommendations

- 14 primary hypotheses w/ some sub-hypotheses designed to determine primary factors affecting survival.
- Categorized based upon the conceptual framework.
- Preliminary research recommendations for retrospective analyses, modeling, intensive field work and diagnostic studies.

Marine Survival Research Planning Workshop

- 3-day workshop in November 2012.
- Over 90 participants, representing multiple disciplines
- 15 member Advisory Panel provided recommendations for critical elements of US-Canada joint research program.
- 2- day ecosystem Indicators for adult return abundance workshop followed w/ over 50 participants.
- Final workshops report released in April 2013

Marine Survival Workshop - Recommendations

- US-Canada research program has ecological and operational merit.
- Focus on the fish but be multi-faceted to account for ecosystem interactions.
- Build around an understanding of bottom-up and top-down processes.
- Use retrospective analyses and modeling to provide a framework for data inputs, ID information gaps, consolidate data, evaluate cumulative effects, narrow field of drivers.
- Implement field work to assess salmon and evaluate prey availability.
- Consider experiments to isolate factors.

What's going on now?

- Research Phase fundraising (identified ~$1.5 million to date)
- Establishing US-Canada workgroups to complete the research components that most benefit from collaboration:
  - retrospective analyses and modeling,
  - data collection methods and standards for diagnostic studies and monitoring,
  - experimental design, and
  - communications and data sharing
- Completing US/Puget Sound specific research components, inc. Puget Sound steelhead-specific work plan

Steelhead Research Planning Overview

Core questions:

1. What is the survival history for Puget Sound steelhead and where is mortality occurring now? How specifically do the abundance and marine survival trends of Puget Sound steelhead populations differ from those in other regions and vary among populations within Puget Sound?

2. What is the direct/proximate cause of mortality in Puget Sound?

3. What is leading to this mortality? What are the root causes? Are they freshwater and/or marine derived?

Steelhead Research Planning: Early Actions

1. Assessment of various early marine mortality hypotheses
2. Detailed assessment of the current declining trends, including more wild pops
3. Puget Sound-wide analysis of acoustic telemetry
4. Retrospective analysis of existing fish characteristics data for correlations with marine survival rates
5. Literature review to identify most likely predators on steelhead smolts
6. Design additional studies

Steelhead Research Planning: thought process

Steelhead dying at high rate in PS

Predation **IS** proximate/ direct cause of mortality

Predation **IS NOT** proximate/ direct cause of mortality

Predator-prey interactions

- Predation has increased
- Buffer prey decreased
- Low juvenile steelhead abundance

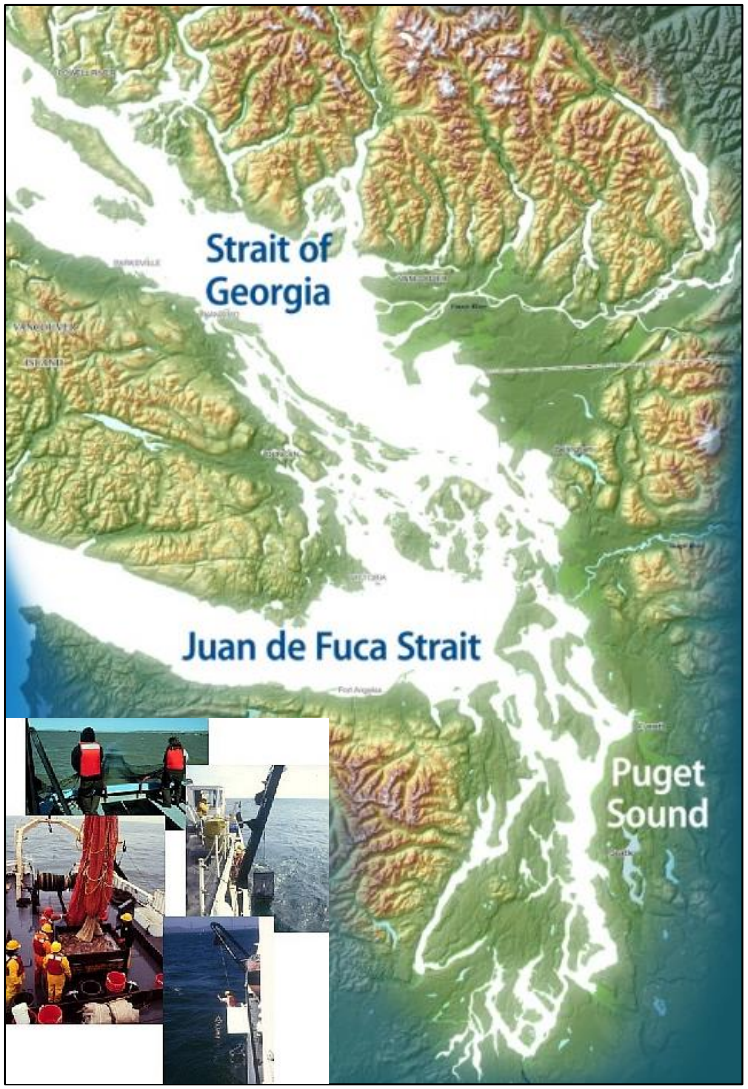
Poor fish condition and/or altered behavior: freshwater (F) or marine (M) derived (ranked)

1. Disease (M/F)
2. Poor water quality/toxics (M/F)
3. Genetic fitness (introgression/outmigrant comp/ effective pop size) (F) – e.g. pred avoidance traits
4. HABs (M)
5. Foraging/Starvation (M)
6. Outmigrant size/growth (F/M)
7. Outmigrant timing (F)
8. Habitat modifications (M)

Additional spatial reference valued

Research Benefits

- Basin-wide, ecosystem-scale approach
- Simultaneous data collection
- Both basin-wide studies and regional comparisons
- Improves collaboration & information sharing for new & existing work. Also, promotes standardization.
- Cost effective



Management Benefits

- Supports multiple recovery and EBM initiatives and enhancement of resource management tools
- Contributes to development of monitoring and evaluation templates

What could it be? Preliminary hypotheses for US Waters of Salish Sea

Where and when is survival most affected?

1. Marine vs freshwater survival
2. Factors affect salmon and steelhead survival differently by location, etc
3. Size-selective mortality regulates survival

What is affecting survival?

ECOSYSTEM FACTORS

4. Circulation patterns affect bottom-up processes / fish behavior
5. Metabolic effect: Temperature affects growth.
6. CO2 concentrations affect fish behavior / prey
7. Harmful Algae Blooms
8. Habitat availability

COMMUNITY FACTORS

9. Prey availability (Insufficient supply, mismatch, competition)
10. Predation
11. Infectious, parasitic and/or noninfectious (toxic derived) disease

POPULATION FACTORS

12. Limited genetic and life-history diversity.

INDIVIDUAL FACTORS

13. Reduced or variable body size/condition during critical growth periods
14. Outmigrant timing has changed

HUMAN FACTORS

15. Bycatch (*Not considered significant*)

Toxic output, habitat alterations, hatchery and aquaculture production embedded

CUMULATIVE EFFECTS

16. Factors may an additive, compensatory, or synergistic effect.

Size and growth matter: Size selective mortality as link to top-down and bottom-up factors affecting survival

a. Size per se (predator avoidance, increase prey 'options')
b. Growth, or growth rate (faster growing fish survive more)

- Size-selective Mortality (SSM) is prevalent with strongest evidence in Chinook and coho
  - Stage-specific size positively correlated to survival
- Can be used to identify critical periods of mortality or growth which influences mort
  - SSM differs among Spp, stocks, life stages

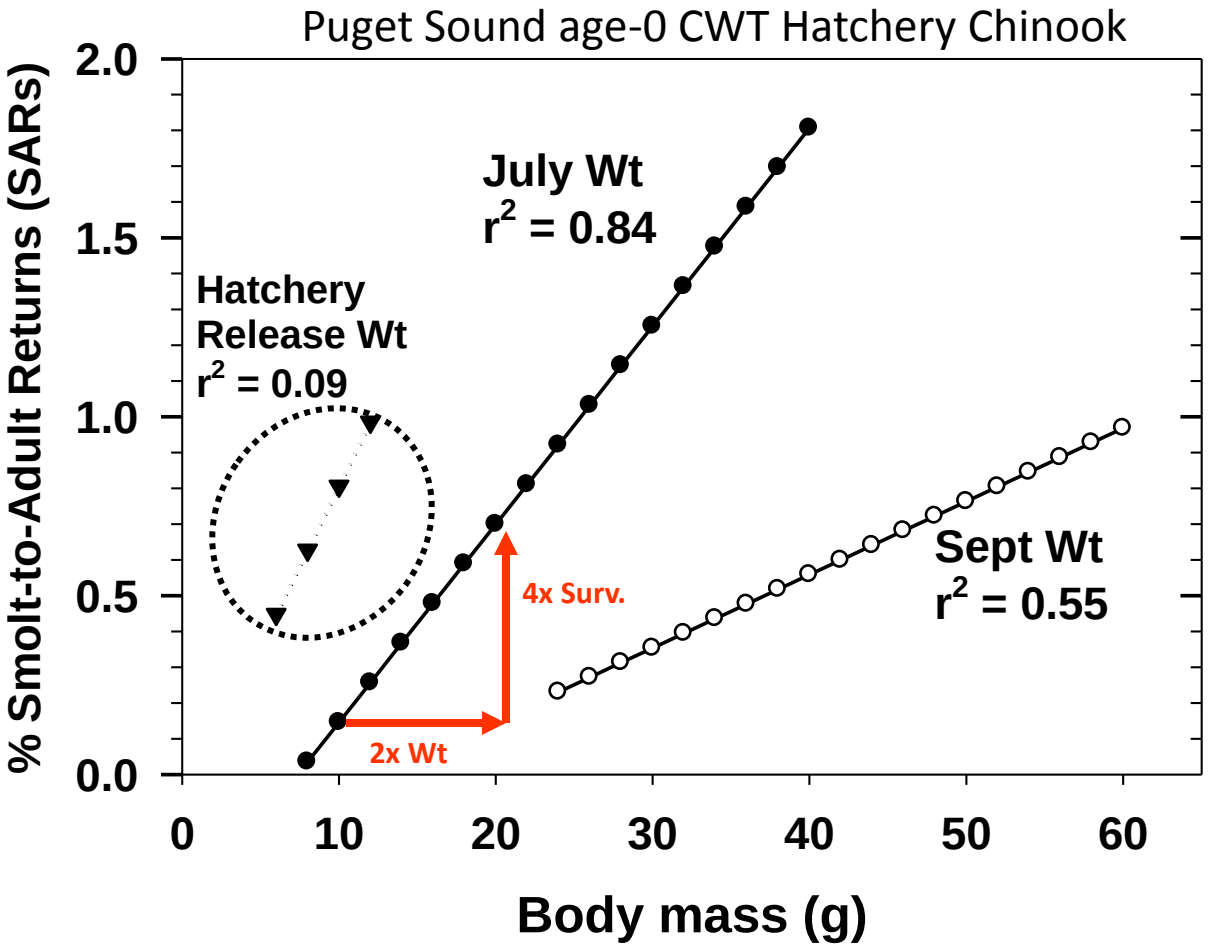
Survival Linked to Size & Growth at Specific Life Stages

Marine survival Strongly linked to Age-0 Wt after 1+ month offshore Growth thru July

2-3 fold Wt gain during 1º pelagic feeding

Weaker pattern in Sept.

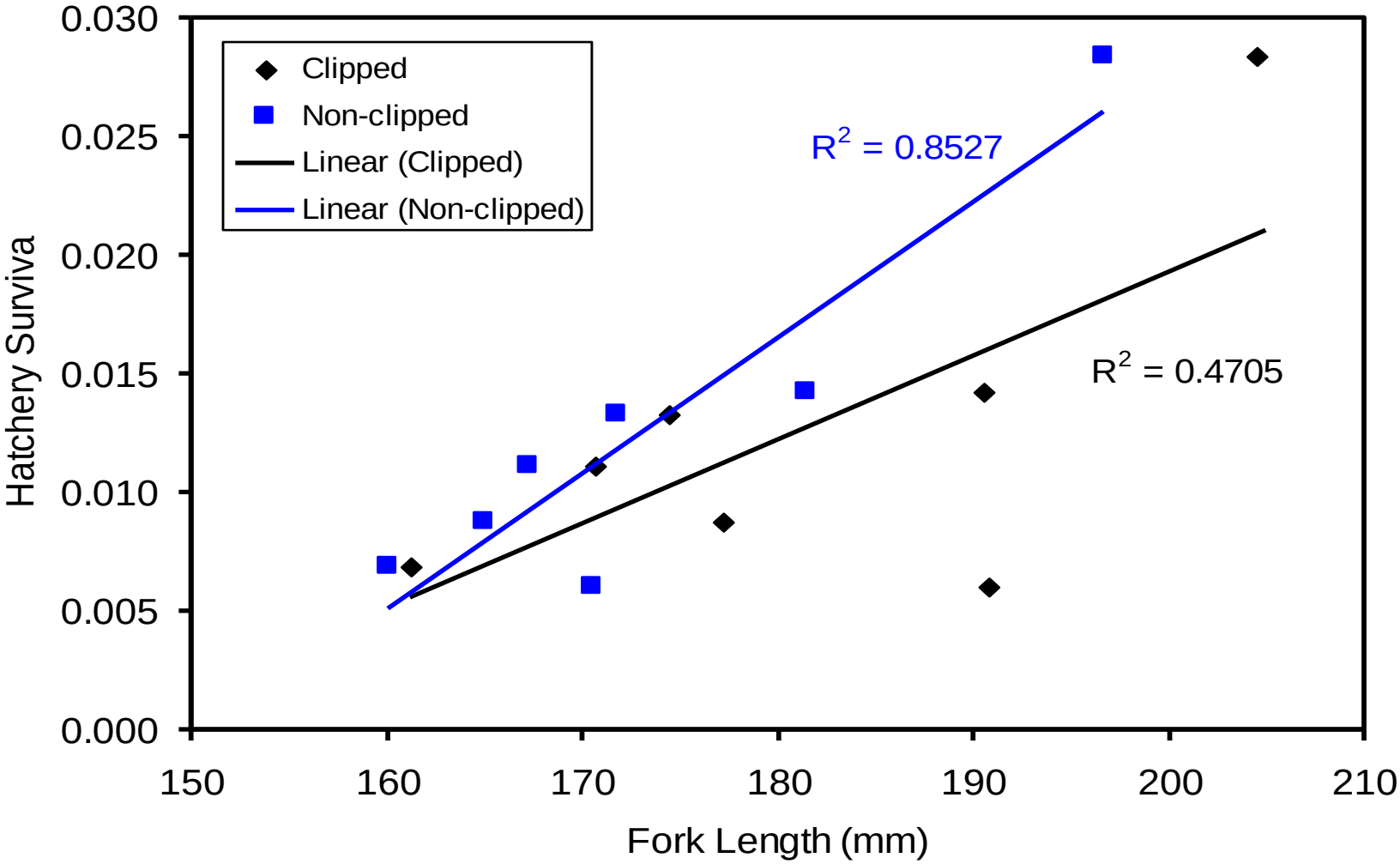
Weak relationship to Size at release



Growth performance at specific life stages can profoundly affect survival in that stage and in subsequent life stages

Duffy & Beauchamp 2011 CJFAS 68:232-240

July surveys – fork length vs Hatchery survival rates for Strait of Georgia coho salmon



Size

- Summer fork lengths generally show a strong positive correlation with the CPUE, abundance & marine survival.
- Fall, not so much

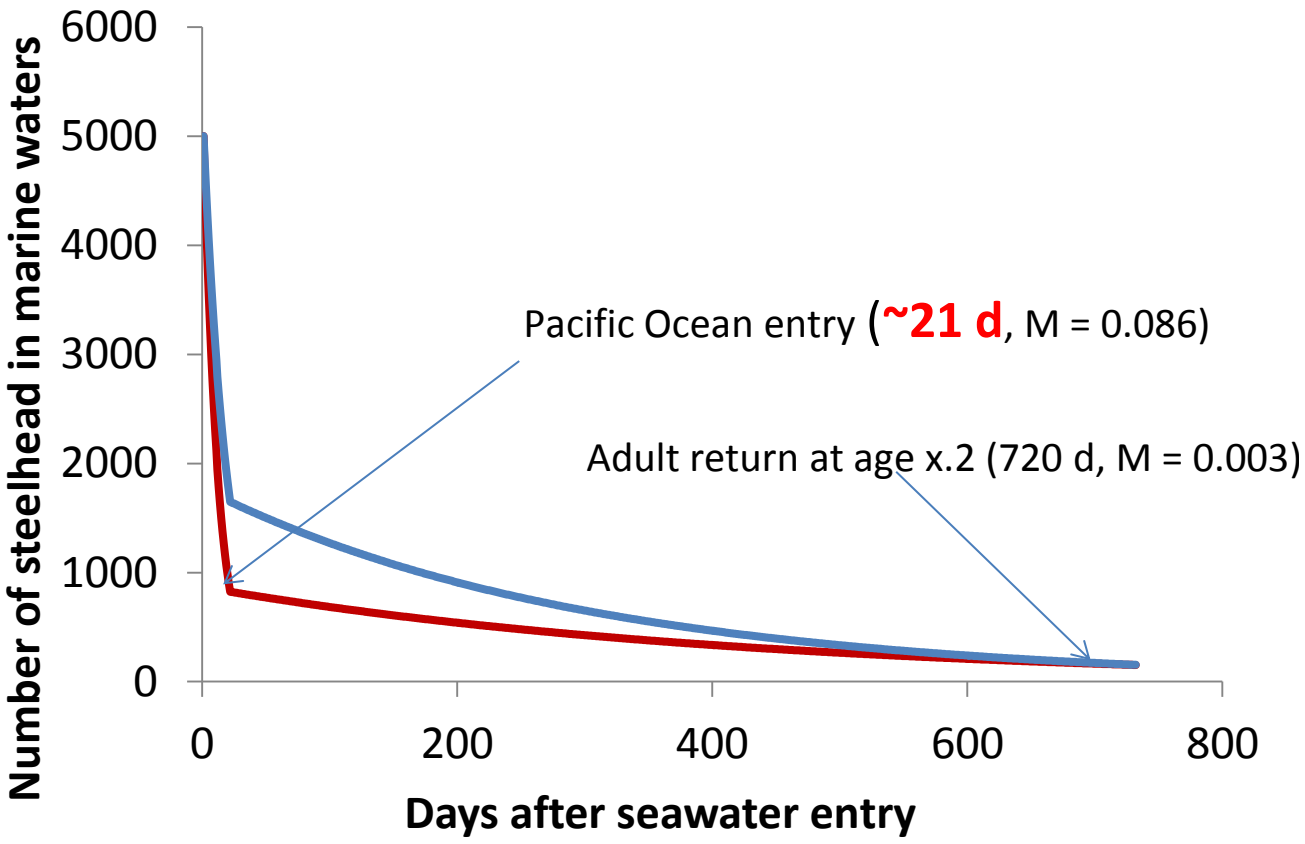
Fork Length (mm) vs		SUMMER DATA			FALL DATA	
		S Georgia	Puget Snd		S Georgia	Puget Snd
Marine Survival	Coho	0.40	0.15		-0.02	-0.17
	Chinook	**0.58**	0.43		-0.10	0.43
Abundance	Coho	**0.55**	0.31		-0.14	0.36
	Chinook	-0.16	**0.50**		-**0.53**	0.27
CPUE	Coho	**0.58**	0.38		-0.26	0.24
	Chinook	-0.17	**0.45**		**-0.43**	**0.53**

* Condition factor not sig. correlated with marine survival.

Steelhead: Puget Sound vs Ocean Survival

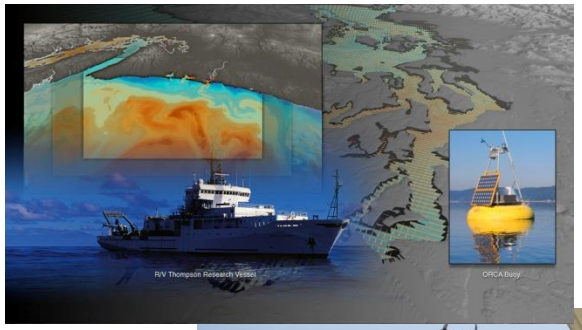
Acoustic Telemetry Results:

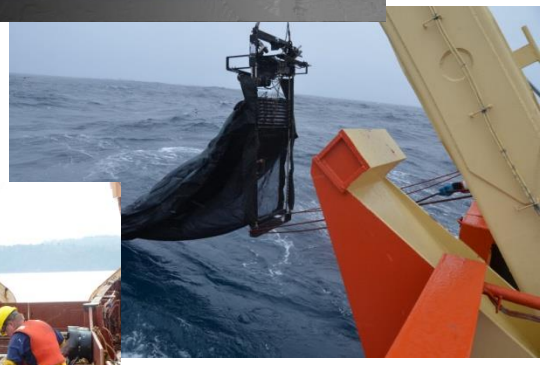
- High rate of instantaneous mortality
- No evidence of size-selective mortality

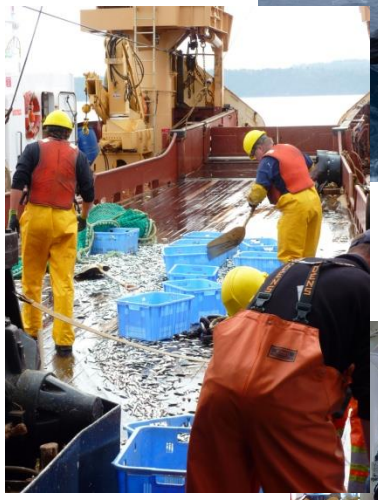


Next Steps

- Finish research planning
  (goal = June 2013)
- Integrate with local research and monitoring planning activities
- Fundraise, fundraise, fundraise
- Implement







Potential Outcomes

Contribute to recovery of wild salmon populations and improving sustainable fisheries, specifically:

- Identify/prioritize actions to increase survival of Salish Sea wild and hatchery salmon;
- improve adult salmon return forecasting and, thusly, natural spawning, harvest, and hatchery management; and
- increase ability to judge effectiveness of freshwater habitat, harvest, hatchery, hydro improvements.

Subsequently, contribute to orcas recovery

What can be done in the San Juans?

- Continue to do juvenile nearshore studies, but be more integrated with broader project

- Determine inhabitant stock composition where practical (e.g., genetics) given that it is a high mixing zone for multiple populations